

## 2. Overview

### National Summary

The United States had the following proved reserves as of December 31, 1998:

- **Crude Oil — 21,034 million barrels**
- **Dry Natural Gas — 164,041 billion cubic feet**
- **Natural Gas Liquids — 7,524 million barrels.**

This Overview summarizes the 1998 proved reserves balances of crude oil, dry natural gas, and natural gas liquids on a National level and provides historical comparisons between 1998 and years past.

**Table 1** lists the estimated annual reserve balances since 1988. From 1997 to 1998, proved reserves of crude oil decreased by 7 percent—the largest percentage decline in 53 years. Proved reserves of dry natural gas decreased by 2 percent, ending a 4-year increasing trend in gas reserves. Natural gas liquids reserves declined 6 percent.

### Crude Oil

Proved reserves of crude oil decreased by 1,512 million barrels in 1998. **Figure 1** shows the crude oil proved reserves levels by major region and **Figure 2** shows the components of reserves changes from 1988 through 1998.

As shown in **Figure 2**, total reserve additions (the positive side of the scale) were down substantially in 1998, as operators reacted to a significant drop in oil prices in the last months of 1998. Net revisions and adjustments were negative for the first time since EIA began recording these data in 1977. Production of crude oil (the negative side of the scale of **Figure 2**) declined slightly for the seventh year in a row.

*Total discoveries* are those reserves attributable to field extensions, new field discoveries, and new reservoir discoveries in old fields. There were 599 million barrels of total discoveries of crude oil proved reserves in 1998. This is less than half of what was discovered in 1997.

*Extensions* added 327 million barrels of proved reserves. This is 31 percent less than in 1997 (477 million barrels) and 25 percent less than the average extensions in the prior 10 years (435 million barrels).

*New field discoveries* were 152 million barrels, substantially less than the 1997 level and 14 percent less than the average volume discovered in the prior 10 years (176 million barrels). New field discoveries in Alaska and the Gulf of Mexico Federal Offshore (143 million barrels) made up 94 percent of the 1998 volume of new field discoveries.

*New reservoir discoveries in old fields* added 120 million barrels of proved reserves. This is more than the 1997 level (119 million barrels) but less than the prior 10-year average for the United States (135 million barrels).

*Revisions and adjustments* deducted 120 million barrels of proved reserves. This is the first negative total for net revisions and adjustments for crude oil since EIA began collecting this data in 1977. In the past 10 years, net revisions and adjustments have added an average of 1,181 million barrels of crude oil proved reserves each year, but this was not the case in 1998. Poor oil economics due to very low oil prices caused many operators to shut-in production and revise their crude oil proved reserves downward.

*Production* removed an estimated 1,991 million barrels of proved reserves from the National total. Production was down 7 percent from 1997's level (2,138 million barrels), and down 17 percent from the prior 10-year average (2,399 million barrels). Reserves additions in 1998 replaced only 24 percent of production.

### Natural Gas

U.S. proved reserves of dry natural gas decreased, ending a four-year increasing trend. Reserves of dry natural gas declined 2 percent from 1997's level to a total of 164,041 billion cubic feet. Dry natural gas reserves declined by 2,547 billion cubic feet in the Lower 48 States, and in Alaska declined by 635 billion cubic feet. **Figure 3** shows the dry natural gas proved reserves levels by major region and **Figure 4** shows the components of reserves changes from 1988 through 1998. Dry natural gas production declined almost 3 percent from 1997 to 1998. Operators were only able to replace 83 percent of 1998's dry gas production with new reserves.

For 1998, U.S. *total discoveries* of dry gas reserves were 11,433 billion cubic feet, down 27 percent from 1997,

**Table 1. Total U.S. Proved Reserves of Crude Oil, Dry Natural Gas, and Natural Gas Liquids, 1988-1998**

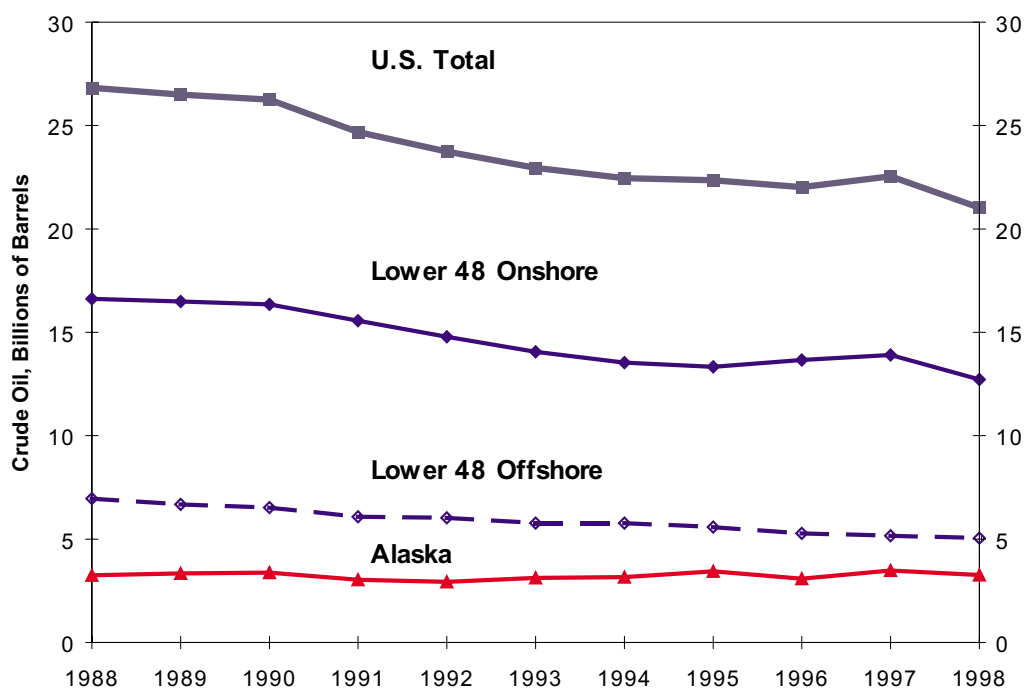
Year	Adjustments (1)	Revision Increases (2)	Revision Decreases (3)	Revisions <sup>a</sup> and Adjustments (4)	Extensions (5)	New Field Discoveries (6)	New Reservoir Discoveries in Old Fields (7)	Total <sup>b</sup> Discoveries (8)	Production (9)	Proved <sup>c</sup> Reserves 12/31 (10)	Change from Prior Year (11)
<b>Crude Oil</b> (million barrels of 42 U.S. gallons)											
1988	364	2,684	1,221	1,827	355	71	127	553	2,811	26,825	-431
1989	213	2,698	1,365	1,546	514	112	90	716	2,586	26,501	-324
1990	86	2,483	1,000	1,569	456	98	135	689	2,505	26,254	-247
1991	163	2,097	1,874	386	365	97	92	554	2,512	24,682	-1,572
1992	290	1,804	1,069	1,025	391	8	85	484	2,446	23,745	-937
1993	271	2,011	1,516	766	356	319	110	785	2,339	22,957	-788
1994	189	2,364	1,357	1,196	397	64	111	572	2,268	22,457	-500
1995	122	1,823	795	1,150	500	114	343	957	2,213	22,351	-106
1996	175	1,723	986	912	543	243	141	927	2,173	22,017	-334
1997	520	1,998	1,084	1,434	477	637	119	1,233	2,138	22,546	+529
1998	-638	2,752	2,234	-120	327	152	120	599	1,991	21,034	-1,512
<b>Dry Natural Gas</b> (billion cubic feet, 14.73 psia, 60° Fahrenheit)											
1988	2,193	23,367	<sup>d</sup> 38,427	-12,867	6,803	1,638	1,909	10,350	16,670	<sup>d</sup> 168,024	-19,187
1989	3,013	26,673	23,643	6,043	6,339	1,450	2,243	10,032	16,983	167,116	-908
1990	1,557	18,981	13,443	7,095	7,952	2,004	2,412	12,368	17,233	169,346	+2,230
1991	2,960	19,890	15,474	7,376	5,090	848	1,604	7,542	17,202	167,062	-2,284
1992	2,235	18,055	11,962	8,328	4,675	649	1,724	7,048	17,423	165,015	-2,047
1993	972	17,597	12,248	6,321	6,103	899	1,866	8,868	17,789	162,415	-2,600
1994	1,945	21,365	15,881	7,429	6,941	1,894	3,480	12,315	18,322	163,837	+1,422
1995	580	20,465	12,731	8,314	6,843	1,666	2,452	10,961	17,966	165,146	+1,309
1996	3,785	17,132	13,046	7,871	7,757	1,451	3,110	12,318	18,861	166,474	+1,328
1997	-590	21,658	16,756	4,312	10,585	2,681	2,382	15,648	19,211	167,223	+749
1998	-1,635	28,003	22,263	4,105	8,197	1,074	2,162	11,433	18,720	164,041	-3,182
<b>Natural Gas Liquids</b> (million barrels of 42 U.S. gallons)											
1988	11	1,168	715	464	268	41	72	381	754	8,238	+91
1989	-277	1,143	1,020	-154	259	83	74	416	731	7,769	-469
1990	-83	827	606	138	299	39	73	411	732	7,586	-183
1991	233	825	695	363	189	25	55	269	754	7,464	-122
1992	225	806	545	486	190	20	64	274	773	7,451	-13
1993	102	764	640	226	245	24	64	333	788	7,222	-229
1994	43	873	676	240	314	54	131	499	791	7,170	-52
1995	192	968	691	469	432	52	67	551	791	7,399	+229
1996	474	844	669	649	451	65	109	625	850	7,823	+424
1997	-15	1,199	910	274	535	114	90	739	864	7,973	+150
1998	-361	1,302	1,094	-153	383	66	88	537	833	7,524	-449

<sup>a</sup>Revisions and adjustments = Col. 1 + Col. 2 - Col. 3.<sup>b</sup>Total discoveries = Col. 5 + Col. 6 + Col. 7.<sup>c</sup>Proved reserves = Col. 10 from prior year + Col. 4 + Col. 8 - Col. 9.<sup>d</sup>An unusually large revision decrease to North Slope dry natural gas reserves was made in 1988. It recognizes some 24.6 trillion cubic feet of downward revisions reported during prior years by operators because of economic and market conditions. The Energy Information Administration (EIA) in previous years carried these reserves in the proved category.

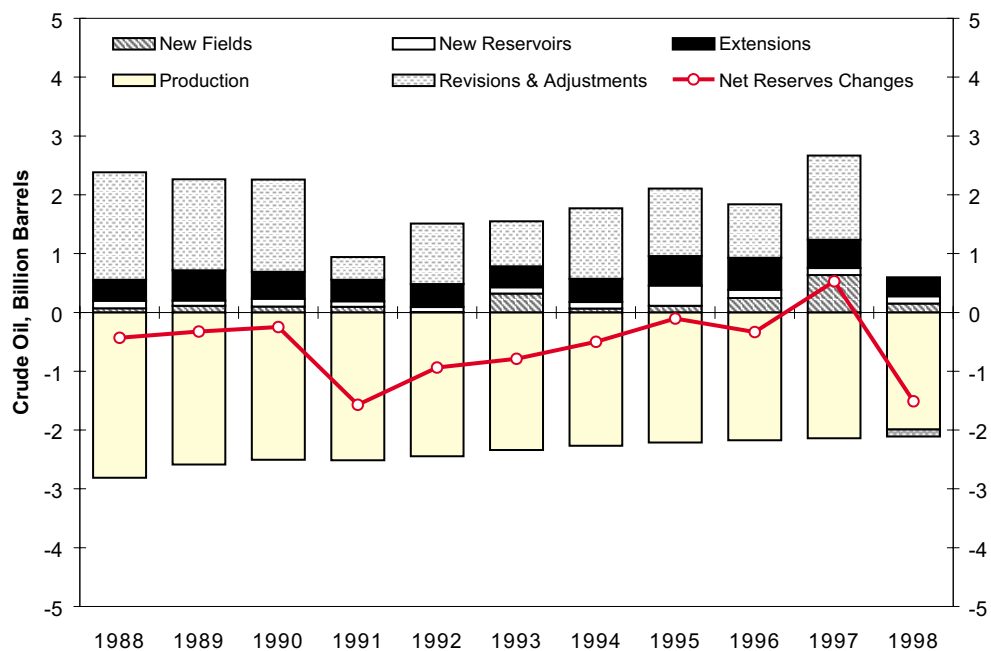
Notes: Old means discovered in a prior year. New means discovered during the report year. The production estimates in this table are based on data reported on Form EIA-23, "Annual Survey of Domestic Oil and Gas Reserves" and Form EIA-64A, "Annual Report of the Origin of Natural Gas Liquids Production." They may differ from the official EIA production data for crude oil, natural gas, and natural gas liquids for 1998 contained in the *Petroleum Supply Annual 1998*, DOE/EIA-0340(98) and the *Natural Gas Annual 1998*, DOE/EIA-0131(98).

Sources: *U.S. Crude Oil, Natural Gas, and Natural Gas Liquids Reserves*, 1988 through 1998 annual reports, DOE/EIA-0216.

**Figure 1. U.S. Crude Oil Proved Reserves, 1988-1998**

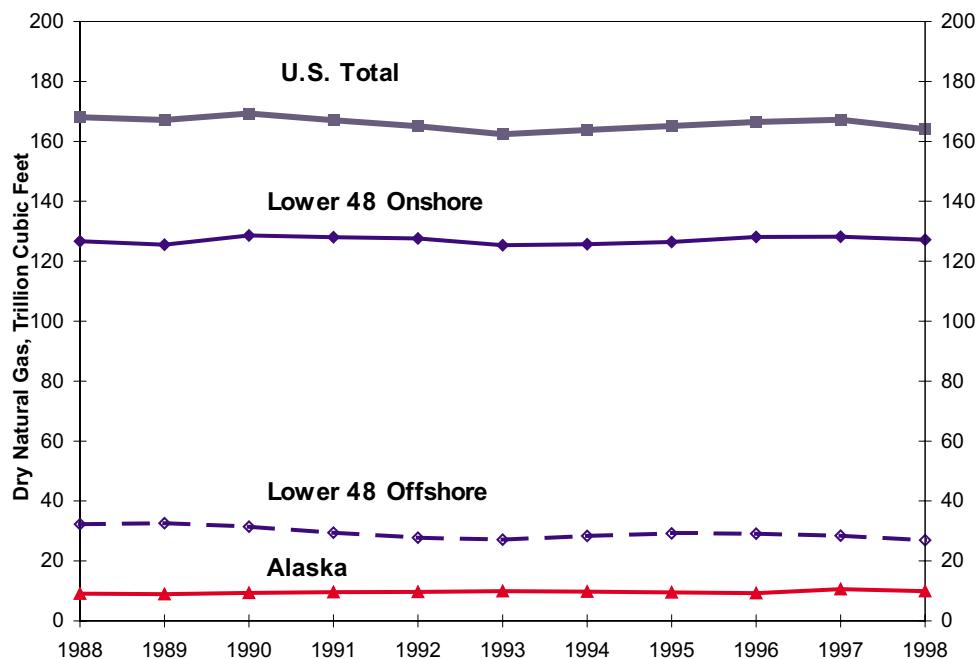


**Figure 2. Components of Reserves Changes for Crude Oil, 1988-1998**

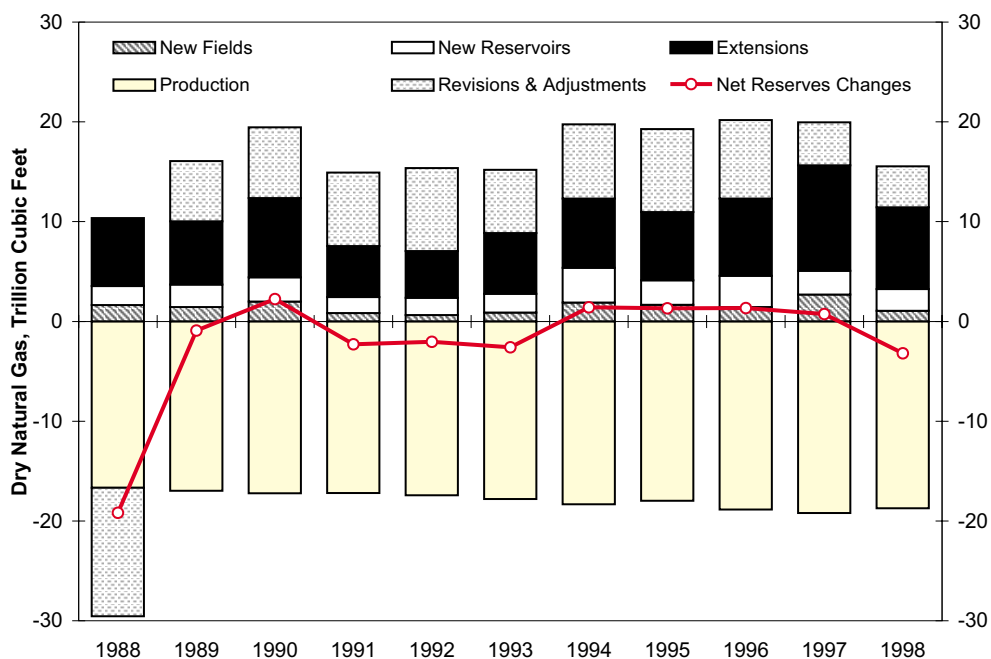


Source: U.S. Crude Oil, Natural Gas, and Natural Gas Liquids Reserves, 1988-1998 annual reports, DOE/EIA-0216.{11-21}

**Figure 3. U.S. Dry Natural Gas Proved Reserves, 1988-1998**



**Figure 4. Components of Reserves Changes for Dry Natural Gas, 1988-1998**



Source: U.S. Crude Oil, Natural Gas, and Natural Gas Liquids Reserves, 1988-1998 annual reports, DOE/EIA-0216.{11-21}

but 6 percent greater than the average annual volume discovered in the past 10 years. *Total discoveries* were 74 percent of all reserve additions in 1998, while *revisions and adjustments* provided the remaining 26 percent.

*Extensions* added 8,197 billion cubic feet of proved reserves. This is 23 percent less than 1997's *extensions* but 19 percent more than the average of *extensions* in the prior 10 years (6,909 billion cubic feet).

*New field discoveries* added 1,074 billion cubic feet of proved reserves. This is 40 percent of what was discovered in 1997 and 29 percent lower than the average volume discovered in the prior 10 years (1,518 billion cubic feet).

*New reservoir discoveries in old fields* added 2,162 billion cubic feet of proved reserves. This is 9 percent less than the volume discovered in 1997, and 7 percent lower than the prior 10-year average (2,318 billion cubic feet).

*Revisions and Adjustments* added 4,105 billion cubic feet of proved reserves. This is 5 percent less than 1997's revisions and adjustments and 18 percent less than the prior 10-year average (5,022 billion cubic feet).

*Production* removed an estimated 18,720 billion cubic feet of proved reserves from the National total. Gas production decreased almost 3 percent compared to 1997.

Coalbed methane gas production and reserves are included in the 1998 totals. However, EIA separately tracks these reserves in order to record the development and performance of this gas source. Coalbed methane reserves increased in 1998 to a volume of 12,179 billion cubic feet. Coalbed methane accounted for 7 percent of 1998 U.S. dry natural gas reserves and 6 percent of 1998 U.S. dry gas production. No Federal tax incentives for new coalbed methane wells have been available for 5 years.

## Natural Gas Liquids

Proved reserves of natural gas liquids decreased 449 million barrels to 7,524 million barrels during 1998—a 6 percent decrease from 1997 levels. A reassessment of the natural gas liquids reserves of Alaska represents the bulk of the 1998 change. **Figure 5** shows the natural gas liquids proved reserves levels by major region and **Figure 6** shows the components of reserves changes from 1988 through 1998.

Operators replaced 46 percent of their 1998 natural gas liquids production with reserve additions. *Total discoveries* added 537 million barrels, but net *revisions and adjustments* took away 153 million barrels.

Total proved reserves of liquid hydrocarbons (crude oil plus natural gas liquids) were 28,558 million barrels in 1998—a 6 percent decrease from the 1997 level. Natural gas liquids represented 26 percent of total liquid hydrocarbon proved reserves in 1998.

## Reserves Changes Since 1977

EIA has collected oil and gas reserves estimates annually since 1977. **Table 2** lists the cumulative totals of the components of reserves changes for crude oil and dry natural gas from 1978 through 1998. **Table 2** contains two sections, one for the lower 48 States and another for the U.S. total (which includes Alaska's contribution). Annual averages for each component of reserves changes are also listed, along with the percentage of that particular component's impact on total U.S. proved reserves. In this section, we compare these averages to the 1998 proved reserves estimates as a means of gauging the past year against history.

**Crude Oil:** Since 1977 U.S. operators have:

- discovered an average of 803 million barrels per year of new reserves
- revised and adjusted their proved reserves upward by an average of 1,295 million barrels per year from *revisions and adjustments*
- ended each year with an average net reduction in U.S. proved reserves of 567 million barrels (the difference between post-1976 average annual production and post-1976 average annual reserve additions) because production has outpaced reserve additions.

Since 1977, crude oil reserves have been primarily sustained by the extension and development of existing fields (called field growth, reserves growth, or the EIA preferred term: proved ultimate recovery appreciation. See the Proved Ultimate Recovery section later in this chapter.) rather than the discovery of new oil fields. Only 8 percent of reserves additions since 1976 were booked as *new field discoveries*. Proved ultimate recovery appreciation is the sum of net revisions and adjustments, extensions, and new reservoirs in old fields. Since 1977, the largest component of proved ultimate recovery appreciation for crude oil is upward *revisions and adjustments*, which accounted for 62 percent of all crude oil reserves additions. The 17,668 million barrels of *total discoveries*

Figure 5. U.S. Natural Gas Liquids Proved Reserves, 1988-1998

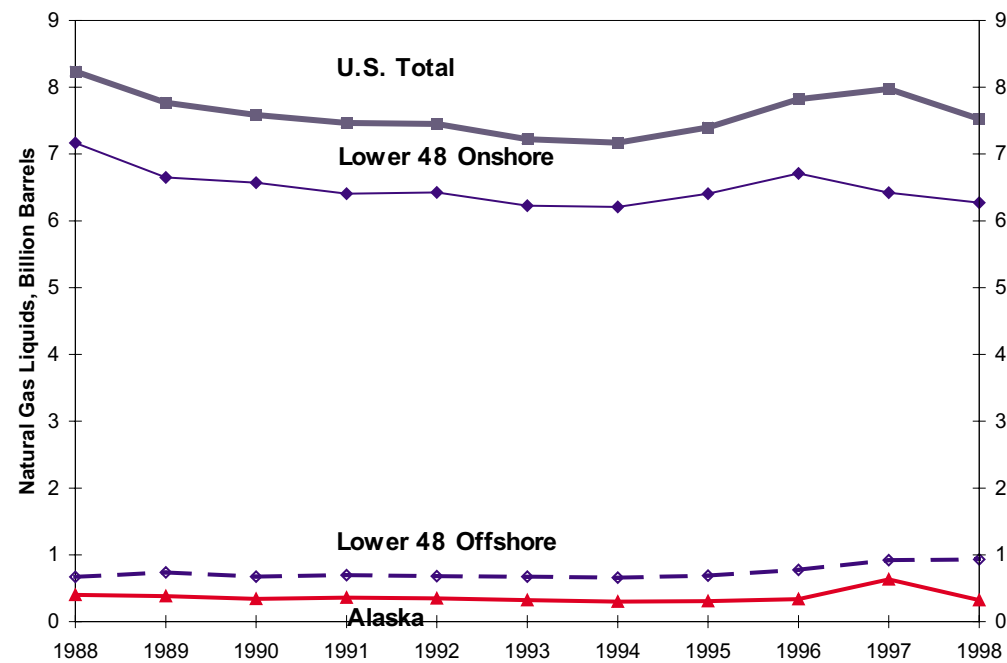
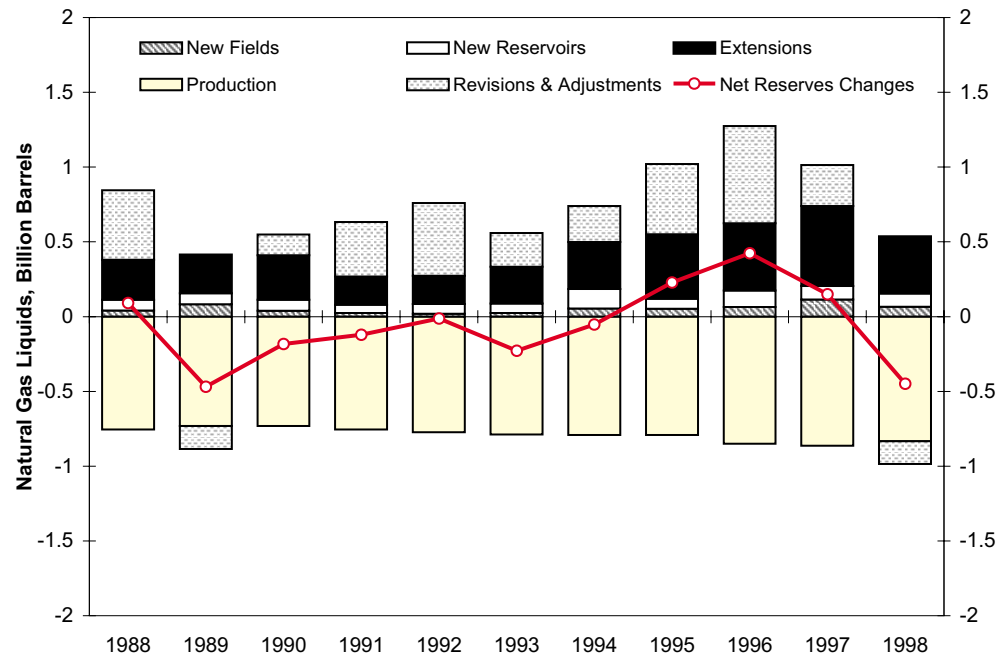


Figure 6. Components of Reserves Changes for Natural Gas Liquids, 1988-1998



Source: U.S. Crude Oil, Natural Gas, and Natural Gas Liquids Reserves, 1988-1998 annual reports, DOE/EIA-0216.{11-21}

**Table 2. Reserves Changes, 1977-1998**

Components of Change	Lower 48 States			U.S. Total		
	Volume	Average per Year	Percent of Reserve Additions	Volume	Average per Year	Percent of Reserve Additions
<b>Crude Oil</b> (million barrels of 42 U.S. gallons)						
<b>Proved Reserves as of 12/31/76</b> . . . . .	<b>24,928</b>	—	—	<b>33,502</b>	—	—
New Field Discoveries . . . . .	3,043	138	8.2	3,634	165	7.9
New Reservoir Discoveries in Old Fields . .	2,999	136	8.1	3,029	138	6.6
Extensions . . . . .	9,856	448	26.7	11,005	500	23.8
<b>Total Discoveries</b> . . . . .	<b>15,898</b>	<b>723</b>	<b>43.1</b>	<b>17,668</b>	<b>803</b>	<b>38.3</b>
Revisions and Adjustments . . . . .	21,024	956	56.9	28,500	1,295	61.7
<b>Total Reserve Additions</b> . . . . .	<b>36,922</b>	<b>1,678</b>	<b>100.0</b>	<b>46,168</b>	<b>2,099</b>	<b>100.0</b>
<b>Production</b> . . . . .	<b>45,868</b>	<b>2,085</b>	<b>124.2</b>	<b>58,636</b>	<b>2,665</b>	<b>127.0</b>
<b>Net Reserve Change</b> . . . . .	<b>-8,946</b>	<b>-407</b>	<b>-24.2</b>	<b>-12,468</b>	<b>-567</b>	<b>-27.0</b>
<b>Dry Natural Gas</b> (billion cubic feet at 14.73 psia and 60° Fahrenheit)						
<b>Proved Reserves as of 12/31/76</b> . . . . .	<b>180,838</b>	—	—	<b>213,278</b>	—	—
New Field Discoveries . . . . .	42,637	1,938	12.0	42,729	1,942	12.6
New Reservoir Discoveries in Old Fields . .	56,300	2,559	15.9	56,665	2,576	16.7
Extensions . . . . .	164,255	7,466	46.3	165,172	7,508	48.6
<b>Total Discoveries</b> . . . . .	<b>263,192</b>	<b>11,963</b>	<b>74.2</b>	<b>264,566</b>	<b>12,026</b>	<b>77.9</b>
Revisions and Adjustments . . . . .	91,507	4,159	25.8	75,114	3,414	22.1
<b>Total Reserve Additions</b> . . . . .	<b>354,699</b>	<b>16,123</b>	<b>100.0</b>	<b>339,680</b>	<b>15,440</b>	<b>100.0</b>
<b>Production</b> . . . . .	<b>381,423</b>	<b>17,337</b>	<b>107.5</b>	<b>388,917</b>	<b>17,678</b>	<b>114.5</b>
<b>Net Reserve Change</b> . . . . .	<b>-26,724</b>	<b>-1,215</b>	<b>-7.5</b>	<b>-49,237</b>	<b>-2,238</b>	<b>-14.5</b>

Source: U.S. Crude Oil, Natural Gas, and Natural Gas Liquids Reserves 1977-1998 annual reports, DOE/EIA-0216.{1-21}

accounted for the remaining 38 percent of reserves additions.

Compared to the average reserves changes since 1977, 1998 was a down year for crude oil discoveries. 1998's *total discoveries* of crude oil (599 million barrels) were 25 percent less the post-1976 U.S. average, and net *revisions and adjustments* were negative for the first time since EIA began publishing this data in 1977. The cause of this large decline in net revisions was poor oil economics, as explained in the Economics and Drilling section of this chapter.

No components of *total discoveries* in 1998 exceeded the post-1976 averages for crude oil.

**Dry Natural Gas:** Since 1977, U.S. operators:

- discovered an average of 12,026 billion cubic feet per year of new reserves
- revised and adjusted their proved reserves upward by an average 3,414 billion cubic feet per year

- had an average net reduction in U.S. reserves of 2,238 billion cubic feet per year.

Like crude oil reserves, natural gas reserves have been sustained primarily by proved ultimate recovery appreciation since 1977. However, *extensions* rather than net *revisions and adjustments* is the largest component. *Extensions* account for 49 percent while *revisions and adjustments* account for only 22 percent of all reserve additions since 1977. In recent years, the percentage of net *revisions and adjustments* has been as high as 39 percent. In 1998, *extensions* were 53 percent of all reserves additions while net *revisions and adjustments* were 26 percent.

Compared to the average reserves changes since 1977, 1998 was a below average year for natural gas reserve additions from *total discoveries*. U.S. total dry natural gas reserves decreased 2 percent, ending a 4-year increasing trend. Operators reported 11,433 billion cubic feet of *total discoveries* of dry natural gas proved reserves—5 percent less than the post-1976 average (12,026 billion cubic feet). However, compared to the

post-1976 U.S. average, *net revisions and adjustments* were 20 percent higher in 1998 (4,105 billion cubic feet).

## Economics and Drilling

**Economics:** Poor oil economics, caused by low crude oil prices, had a strong negative impact on domestic U.S. proved reserves in 1998. A direct consequence of the low oil prices was reduced 1998 drilling levels. This section describes the drastic price behavior in 1998 and the following section addresses drilling.

**Table 3** lists the average annual domestic wellhead prices of crude oil and natural gas, as well as the average number of active rotary drilling rigs, from 1970 to 1998.

The U.S. crude oil first purchase price (less the Alaskan North Slope) started at an average of \$13.48 per barrel in January 1998, but declined to \$10.00 per barrel by June. Prices increased slightly to \$11.32 by October 1998, but then fell below the \$10 mark to \$8.05 per barrel in December. The average U.S. crude oil first purchase price (less the Alaskan North Slope) declined from an average \$17.23 in 1997 to \$10.88 per barrel in 1998.

**Table 3. U.S. Average Annual Domestic Wellhead Prices for Crude Oil and Natural Gas, and the Average Number of Active Rotary Drilling Rigs, 1970-1998**

Year	Crude Oil		Natural Gas		Number of Rigs
	Current	1998 Constant	Current	1998 Constant	
	(dollars per barrel)		(dollars per thousand cubic feet)		
1970	3.18	11.71	0.17	0.63	1,028
1971	3.39	11.87	0.18	0.63	976
1972	3.39	11.40	0.19	0.64	1,107
1973	3.89	12.38	0.22	0.70	1,194
1974	6.87	20.11	0.30	0.88	1,472
1975	7.67	20.48	0.44	1.18	1,660
1976	8.19	20.70	0.58	1.47	1,658
1977	8.57	20.38	0.79	1.88	2,001
1978	9.00	19.89	0.91	2.01	2,259
1979	12.64	25.76	1.18	2.40	2,177
1980	21.59	40.28	1.59	2.97	2,909
1981	31.77	54.33	1.98	3.39	3,970
1982	28.52	45.85	2.46	3.95	3,105
1983	26.19	40.38	2.59	3.99	2,232
1984	25.88	38.43	2.66	3.95	2,428
1985	24.09	34.54	2.51	3.60	1,980
1986	12.51	17.49	1.94	2.71	964
1987	15.40	20.89	1.67	2.26	936
1988	12.58	16.47	1.69	2.21	936
1989	15.86	19.93	1.69	2.12	869
1990	20.03	24.12	1.71	2.06	1,010
1991	16.54	19.16	1.64	1.90	860
1992	15.99	18.02	1.74	1.96	721
1993	14.25	15.65	2.04	2.24	754
1994	13.19	14.14	1.85	1.98	775
1995	14.62	15.33	1.55	1.62	723
1996	R18.46	19.00	2.17	2.23	779
1997	R17.23	17.40	R2.32	2.34	943
1998	10.88	10.88	1.96	1.96	827

R=Revised data.

Sources: Current dollars and number of rigs: *Monthly Energy Review November 1999*, DOE/EIA-0035(99/11). 1998 constant dollars: U.S. Department of Commerce, Bureau of Economic Analysis, Gross Domestic Product Implicit Price Deflators, June 1999.



Oil prices vary by region. In Texas the average 1998 crude oil first purchase price was \$12.28 per barrel, while in California it was \$9.61 per barrel, and only \$8.49 per barrel on the Alaskan North Slope. The lowest average crude oil first purchase price in 1998 was for Federal Offshore California oil—\$6.98 per barrel.{22}

The average annual wellhead natural gas price decreased from \$2.32 in 1997 to \$1.96 per thousand cubic feet in 1998. Gas prices started at \$1.99 per thousand cubic feet in January 1998 and rose to \$2.22 per thousand cubic feet by April 1998 (the highest average price of the year). In June, prices dipped to \$1.97 but crept up to \$2.08 in July. After July, prices hovered around \$1.85 per thousand cubic feet, and then declined in December to \$1.73 per thousand cubic feet—the lowest average price for the year.{23}

**Drilling:** From 1997 to 1998, the annual average active rig count decreased from 943 to 827 (**Table 3**). The rig count remains well below the peak activity level of 1981 (average 3,970 rigs) but, it must be realized that a comparison of only the bulk number of wells drilled is not representative of drilling's impact on reserves levels over time. Operators are now using significantly improved drilling and seismic exploration technology to dramatically increase their drilling success rate.

Looking first at exploratory wells, there were 2,691 exploratory wells drilled in 1998 (**Table 4**). Of these, 11 percent were oil wells, 21 percent were gas wells, and 67 percent were dry holes. The total (which includes dry holes) was 12 percent less than in 1997.

The number of active rigs decreased in 1998, resulting in 12 percent fewer successful exploratory wells than in 1997. There were 7 percent more exploratory gas wells (**Figure 7**) and 29 percent fewer exploratory oil wells (**Figure 8**) than in 1997. The number of successful development wells decreased 32 percent for oil and increased 7 percent for gas from 1997.

**Figures 9 and 10** show the average volume of discoveries per exploratory well for dry natural gas and oil, respectively, since 1977. Both the average volume of gas discoveries per exploratory well and the average volume of oil discoveries per exploratory well in 1998 decreased to levels closer to those of 1996. Altogether there were an estimated 24,083 exploratory and development wells drilled in 1998, 12 percent less than in 1997 and 8 percent less than the average number of wells drilled annually in the prior 10 years (26,143).

For the sixth year in a row, the number of gas well completions exceeded the number of oil well completions in both the exploratory and development categories.

## Mergers and Acquisitions

Not all the notable activity in 1998 occurred in frontier drilling areas, some occurred around the boardroom tables of major oil and gas corporations. Over 1,400 major field ownership transactions, mergers, and acquisitions were announced in 1998. The following large mergers were announced in 1998, and are expected to have a major impact on the energy industry in the future:

On August 11, 1998, British Petroleum announced that it would acquire Amoco for \$48.2 billion in stock, the largest oil industry merger and the largest foreign take-over of a U.S. company to date. The company will be known as BP Amoco, and it will be the world's third-largest multinational oil company in terms of net income behind Exxon and Royal Dutch/Shell Group.{24}

On December 2, 1998, Exxon Corporation agreed to buy Mobil Corporation for approximately \$75.4 billion, making the company the largest corporation in the U.S. The company will be known as Exxon Mobil, and said they expect to cut about 9,000 jobs from their combined worldwide workforce of 122,700 and to close offices, saving \$730 million. The merger comes in the context of low oil prices, which have hurt profits at many oil companies.{25}

On December 30, 1998, U.S. federal regulators approved the proposed purchase of Amoco by British Petroleum P.L.C. after extracting a handful of antitrust concessions from the new company. With a market capitalization of about \$140 billion, BP Amoco would rank third in the global oil industry behind the proposed Exxon-Mobil merger and Royal Dutch/Shell.{26}

## Reserve-to-Production Ratio and Ultimate Recovery

### R/P Ratios

The relationship between proved reserves and production levels, expressed as the ratio of reserves to production (R/P ratio) is often used in analyses. For a

**Table 4. U.S. Exploratory and Development Well Completions,<sup>a</sup> 1970-1998**

Year	Exploratory <sup>b</sup>				Total Exploratory and Development <sup>b</sup>			
	Oil	Gas	Dry	Total	Oil	Gas	Dry	Total
1970	763	478	6,193	7,434	13,043	4,031	11,099	28,173
1971	664	472	5,995	7,131	11,903	3,983	10,382	26,268
1972	690	659	6,202	7,551	11,437	5,484	11,013	27,934
1973	642	1,067	5,952	7,661	10,167	6,933	10,320	27,420
1974	859	1,190	6,833	8,882	13,647	7,138	12,116	32,901
1975	982	1,248	7,129	9,359	16,948	8,127	13,646	38,721
1976	1,086	1,346	6,772	9,204	17,688	9,409	13,758	40,855
1977	1,164	1,548	7,283	9,995	18,745	12,122	14,985	45,852
1978	1,171	1,771	7,965	10,907	19,181	14,413	16,551	50,145
1979	1,321	1,907	7,437	10,665	20,851	15,254	16,099	52,204
1980	1,764	2,081	9,039	12,884	32,639	17,333	20,638	70,610
1981	2,636	2,514	12,349	17,499	43,598	20,166	27,789	91,553
1982	2,431	2,125	11,247	15,803	39,199	18,979	26,219	84,397
1983	2,023	1,593	10,148	13,764	37,120	14,564	24,153	75,837
1984	2,198	1,521	11,278	14,997	42,605	17,127	25,681	85,413
1985	1,679	1,190	8,924	11,793	35,118	14,168	21,056	70,342
1986	1,084	793	5,549	7,426	19,097	8,516	12,678	40,291
1987	925	754	5,049	6,728	16,164	8,055	11,112	35,331
1988	855	732	4,693	6,280	13,636	8,555	10,041	32,232
1989	607	705	3,924	5,236	10,204	9,539	8,188	27,931
1990	654	689	3,715	5,058	12,198	11,044	8,313	31,555
1991	592	534	3,314	4,440	11,770	9,526	7,596	28,892
1992	493	423	2,513	3,429	8,757	8,209	6,118	23,084
1993	502	548	2,469	3,519	8,407	10,017	6,328	24,752
1994	570	726	2,405	3,701	6,721	9,538	5,307	21,566
1995	542	570	2,198	3,310	7,627	8,354	5,075	21,056
1996	483	570	2,136	3,189	8,314	9,302	5,282	22,898
1997	428	536	2,110	3,074	10,436	11,327	5,702	27,465
1998	303	572	1,816	2,691	7,064	12,106	4,913	24,083

<sup>a</sup>Excludes service wells and stratigraphic and core testing.

<sup>b</sup>All drilling counts for the years 1973-1997 have been revised.

Notes: Estimates are based on well completions taken from American Petroleum Institute data tapes through October 1999. Due to the method of estimation, data shown are frequently revised. Data are no longer rounded to nearest 10 wells.

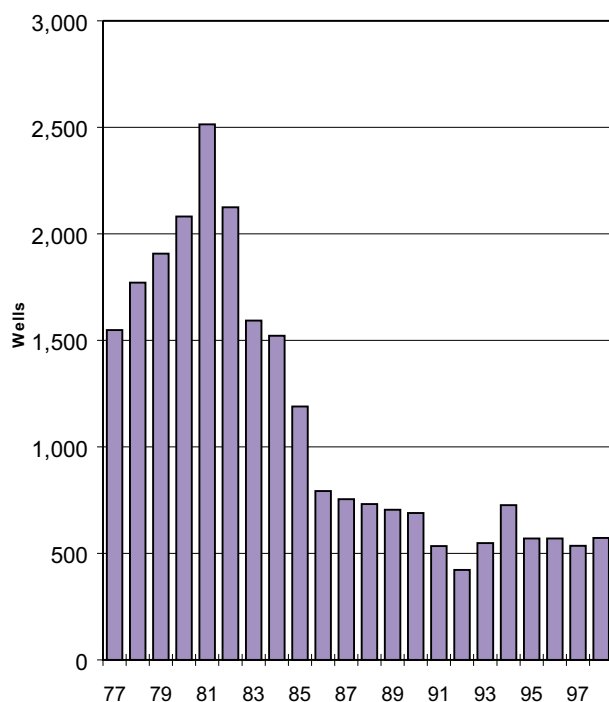
Sources: Years 1970-1972: Energy Information Administration, Office of Oil and Gas. Years 1973-1998: *Monthly Energy Review* November 1999, DOE/EIA-0035(99/11).

mature producing area, the R/P ratio tends to be reasonably stable, so that the proved reserves at the end of a year serve as a rough guide to the production level that can be maintained during the following year. Operators report data which yield R/P ratios that vary widely by area depending upon:

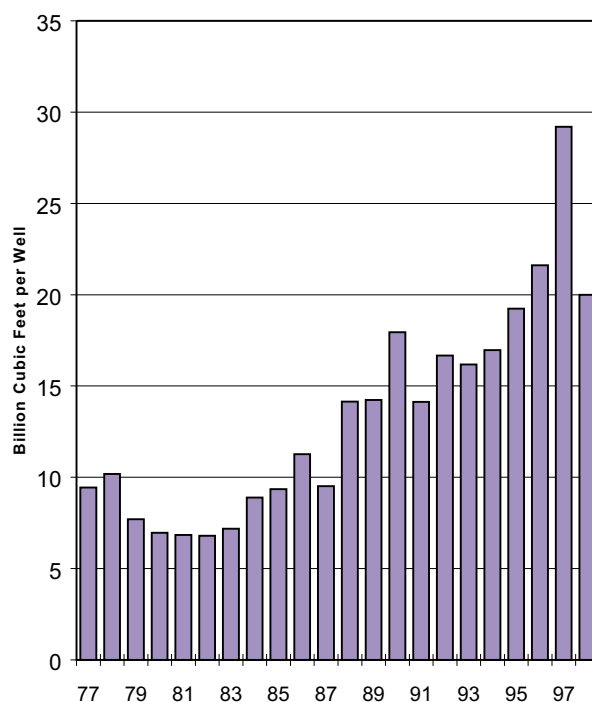
- category of operator
- geology and economics
- number and size of new discoveries
- amount of drilling that has occurred.

R/P ratios are an indication of the state of development in an area and, over time, the ratios change. For example, when the Alaskan North Slope oil reserves were booked, the U.S. R/P ratio for crude oil increased because significant production from these reserves did not begin until 7 years after booking due to the need to first build the Trans Alaska pipeline. The U.S. R/P ratio for crude oil decreased from 11.1-to-1 to 9.4-to-1 between 1977 and 1982, as Alaskan North Slope oil production reached high levels.

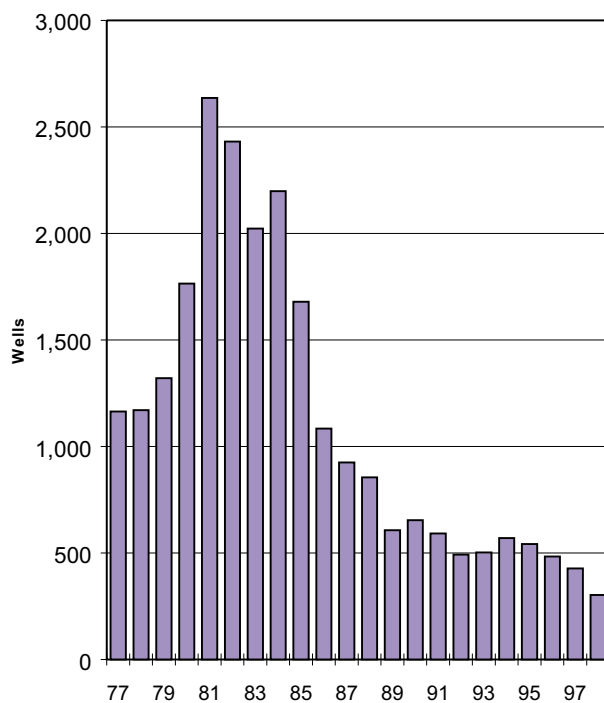
**Figure 7. U.S. Exploratory Gas Well Completions, 1977-1998**



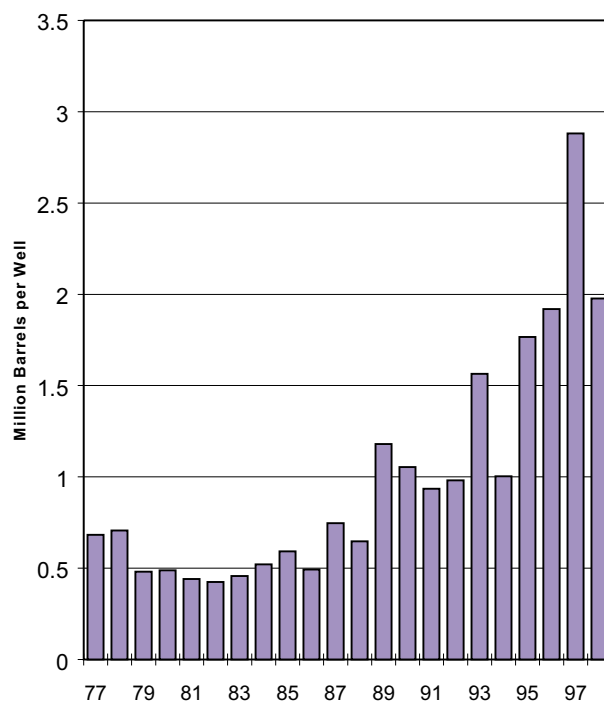
**Figure 9. U.S. Total Discoveries of Dry Natural Gas per Exploratory Gas Well Completion, 1977-1998**



**Figure 8. U.S. Exploratory Oil Well Completions, 1977-1998**



**Figure 10. U.S. Total Discoveries of Crude Oil per Exploratory Oil Well Completion, 1977-1998**



Source: Energy Information Administration, Office of Oil and Gas.

In 1998, both U.S. crude oil proved reserves and oil production decreased—resulting in no significant change in the National average R/P ratio (10.6).

**Figure 11** shows the U.S. R/P ratio trend for crude oil since 1945. After World War II, increased drilling and discoveries led to a greater R/P ratio. Later, when drilling found fewer reserves than were produced, the ratio became smaller. R/P ratios also vary geographically. Less developed areas of the country, such as the Pacific offshore, have higher R/P ratios for crude oil than the 1998 National average of 10.6-to-1. Other areas with relatively high R/P ratios are the Permian Basin of Texas and New Mexico, and California, where enhanced oil recovery techniques such as carbon dioxide (CO<sub>2</sub>) injection or steamflooding have improved recoverability of oil in old, mature fields. Areas that have the lowest R/P ratios, like the Mid-Continent region, usually have many older fields. There, new technologies such as horizontal drilling have helped add reserves equivalent to the annual production, keeping the regional reserves and R/P ratio for oil relatively stable.

**Figure 12** shows the historical R/P ratio for wet natural gas since 1945. Prior to 1945, R/P ratios were very high since the interstate pipeline infrastructure was not well developed. The market for and production of natural gas grew rapidly after World War II, lowering the R/P ratio. The U.S. average R/P ratio for natural gas increased in 1998, as reserves decreased, but not more than the decline in production.

Different marketing, transportation, and production characteristics for gas are seen when looking at regional average R/P ratios, compared to the 1998 U.S. average R/P ratio of about 8.8-to-1. The areas with the higher range of R/P ratios are the less developed or less productive areas of the country, such as the Pacific offshore and the Rockies, and also include areas such as Alabama and Colorado where considerable booking of coalbed methane reserves has recently occurred. Several major gas producing areas have R/P ratios below the National average, particularly Texas, the Gulf of Mexico Federal Offshore, and Oklahoma. The R/P ratio of these three areas combined increased from 6.8-to-1 in 1997 to 6.9-to-1 in 1998, and is below the National 1998 average.

## Proved Ultimate Recovery

EIA has in past reports defined Ultimate Recovery as the sum of proved reserves and cumulative production. However, despite EIA's clear definition,

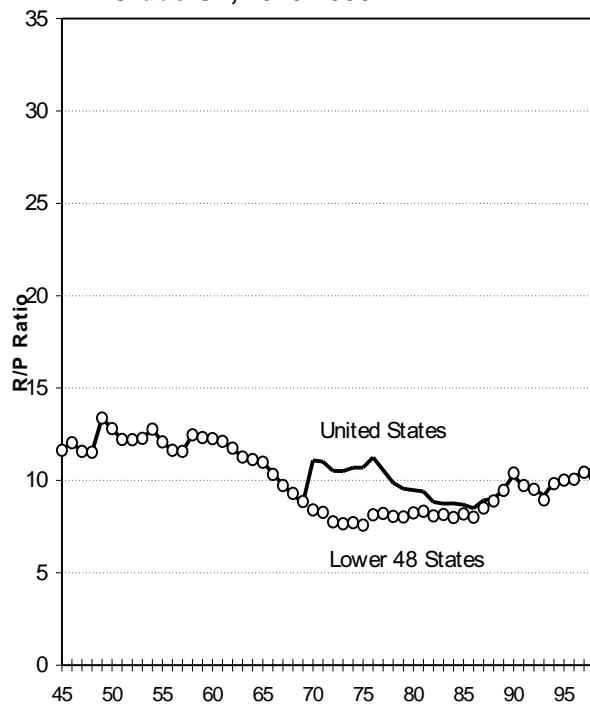
the volume presented by EIA has often been misused or misinterpreted as the maximum recoverable volume of resources for an area. This neglects the addition of proved reserves over time through ultimate recovery appreciation (a.k.a. reserves growth or field growth) and has led some to make overly-pessimistic resource assessments for the United States. EIA is therefore introducing a new term, *Proved Ultimate Recovery*:

**Proved Ultimate Recovery** is the sum of proved reserves and cumulative production. It is expected to change over time for any field, group of fields, State, or Country. Proved Ultimate Recovery does not represent the maximum recoverable volume of resources for an area. It is instead a gauge of how much has already been produced plus proved reserves. Proved reserves of crude oil or natural gas are the estimated quantities of petroleum which geological and engineering data demonstrate with reasonable certainty to be recoverable in future years from known reservoirs under existing economic and operating conditions. When deterministic proved reserves estimation methods are used, the term reasonable certainty is intended to express a high degree of confidence that the estimated quantities will be recovered. When probabilistic methods are used there should be at least a 90 percent probability that the actual quantities recovered will exceed the estimate.

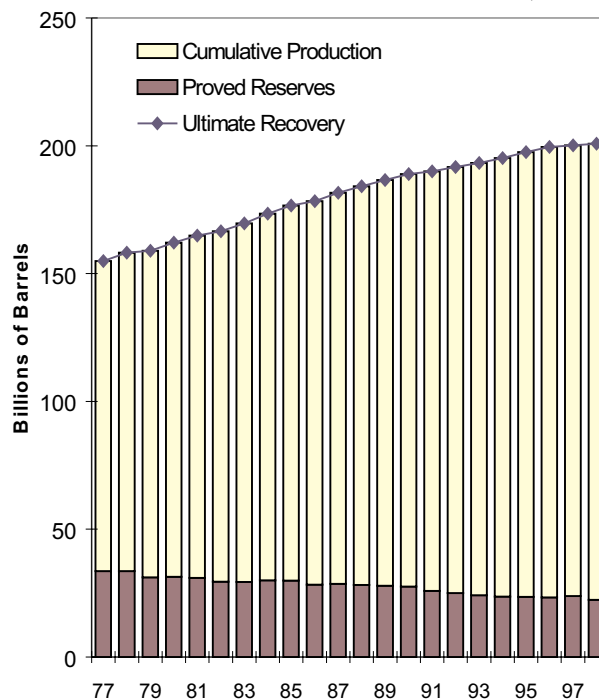
**Figures 13 and 14** show successive estimates of proved ultimate recovery and its components, proved reserves and cumulative production, for crude oil plus lease condensate, and wet natural gas, from 1977 through 1998. They illustrate the continued appreciation (growth) of proved ultimate recovery over time.

In 1977, U.S. crude oil and lease condensate proved reserves were 33,615 million barrels. Cumulative production of crude oil and lease condensate for 1977 through 1998 was 59,205 million barrels. This substantially exceeds the 1977 proved reserves, but at the end of 1998 there were still 22,370 million barrels of crude oil and lease condensate proved reserves. Therefore, the Nation's estimated proved ultimate recovery of crude oil was fundamentally increased during this period owing to the *proved ultimate recovery appreciation* process (continued development of old fields). In fact, only 8 percent of proved reserves additions of crude oil were booked as *new field discoveries* from 1976 through 1998. The rest was from proved reserves categories included in the proved ultimate recovery appreciation process (*new reservoir discoveries in old fields, extensions, and revisions and*

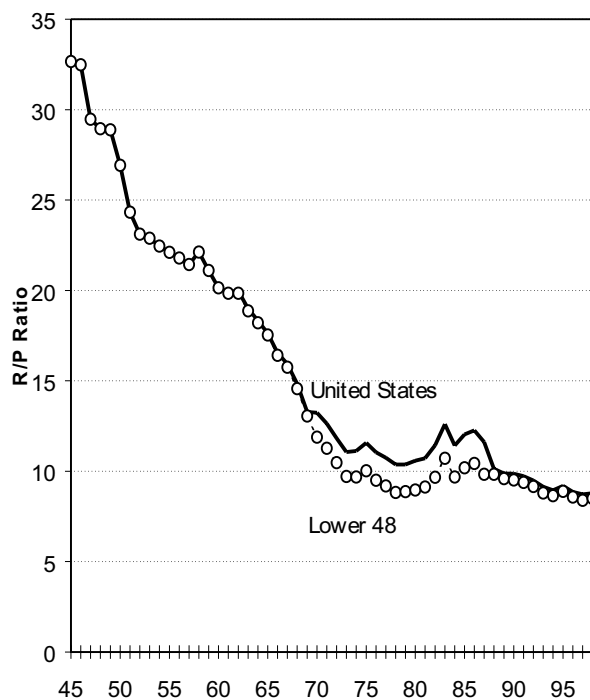
**Figure 11. Reserves-to-Production Ratios for Crude Oil, 1945-1998**



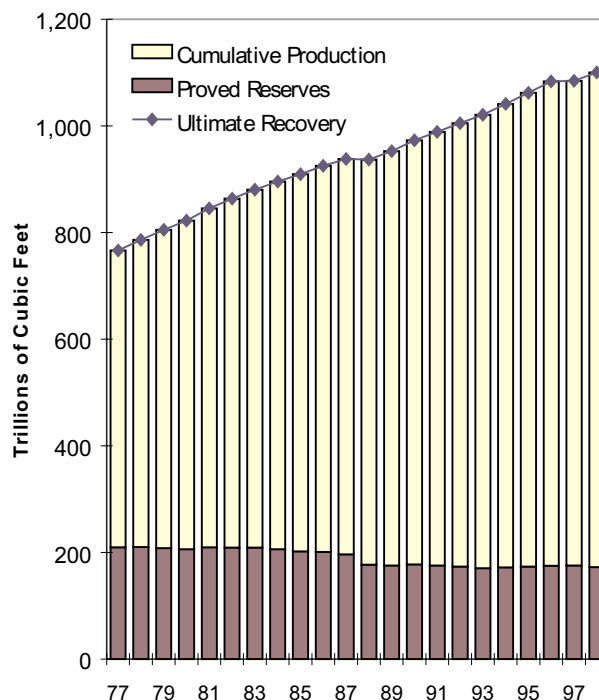
**Figure 13. Components of Proved Ultimate Recovery for Crude Oil and Lease Condensate, 1977-1998**



**Figure 12. Reserves-to-Production Ratios for Wet Natural Gas, 1945-1998**



**Figure 14. Components of Proved Ultimate Recovery for Wet Natural Gas, 1977-1998**



Sources: Annual reserves and production - American Petroleum Institute and American Gas Association (1945-1976){27} and Energy Information Administration, Office of Oil and Gas (1977-1998){1-21}. Cumulative production: *U.S. Oil and Gas Reserves by Year of Field Discovery* (1977-1988){28}

**Table 5. International Oil and Natural Gas Reserves as of December 31, 1998**

Oil (million barrels)				Natural Gas (billion cubic feet)			
Rank <sup>a</sup>	Country	Oil & Gas Journal	World Oil	Rank <sup>b</sup>	Country	Oil & Gas Journal	World Oil
1	Saudi Arabia <sup>c</sup>	<sup>d</sup> 261,500	<sup>d</sup> 261,425	1	Former U.S.S.R.	1,977,000	1,904,350
2	Iraq <sup>c</sup>	112,500	98,975	2	Iran <sup>c</sup>	812,300	812,238
3	Kuwait <sup>c</sup>	<sup>d</sup> 96,500	<sup>d</sup> 94,680	3	Qatar <sup>c</sup>	300,000	395,000
4	Iran <sup>c</sup>	89,700	92,870	4	United Arab Emirates <sup>c</sup>	212,500	202,550
5	United Arab Emirates <sup>c</sup>	97,800	63,505	5	Saudi Arabia <sup>c</sup>	<sup>d</sup> 204,500	<sup>d</sup> 208,000
6	Former U.S.S.R.	57,000	66,641	<b>6</b>	<b>United States</b>	<b><sup>e</sup>167,223</b>	<b>167,772</b>
7	Venezuela <sup>c</sup>	72,600	45,500	7	Venezuela <sup>c</sup>	142,500	146,571
8	Mexico	47,822	28,399	8	Algeria <sup>c</sup>	130,300	137,500
9	China	24,000	33,520	9	Nigeria <sup>c</sup>	124,000	124,000
10	Libya <sup>c</sup>	29,500	26,900	10	Iraq <sup>c</sup>	109,800	112,600
<b>Top 10 Total</b>		<b>888,724</b>	<b>810,090</b>	<b>Top 10 Total</b>		<b>4,179,823</b>	<b>4,210,581</b>
11	Nigeria <sup>c</sup>	22,500	22,500	11	Malaysia	81,700	85,831
<b>12</b>	<b>United States</b>	<b><sup>e</sup>22,546</b>	<b>22,013</b>	12	Indonesia <sup>c</sup>	72,268	77,066
13	Norway	10,913	11,901	13	Canada	63,874	63,555
14	Algeria <sup>c</sup>	9,200	13,000	14	Netherlands	63,107	62,516
15	Brazil	7,106	7,500	15	Kuwait <sup>c</sup>	<sup>d</sup> 52,200	<sup>d</sup> 56,350
16	Indonesia <sup>c</sup>	4,980	8,637	16	Mexico	63,456	30,300
17	Oman	5,283	5,564	17	Libya <sup>c</sup>	46,400	46,300
18	Canada	4,931	5,582	18	China	48,300	42,360
19	United Kingdom	5,191	5,153	19	Norway	41,424	43,627
20	Angola	5,412	4,030	20	Australia	44,638	28,410
21	Qatar <sup>c</sup>	3,700	5,338	21	Egypt	31,500	37,205
22	Malaysia	3,900	4,645	22	Oman	28,416	29,100
23	Egypt	3,500	3,710	23	United Kingdom	27,016	26,652
24	India	3,972	3,027	24	Argentina	24,148	24,247
25	Yemen	4,000	1,850	25	Pakistan	21,600	21,600
<b>Top 25 Total</b>		<b>1,006,056</b>	<b>931,988</b>	<b>Top 25 Total</b>		<b>4,889,670</b>	<b>4,881,700</b>
<b>OPEC Total</b>		<b>800,480</b>	<b>733,330</b>	<b>OPEC Total</b>		<b>2,206,768</b>	<b>2,318,175</b>
<b>World Total</b>		<b>1,034,667</b>	<b>968,513</b>	<b>World Total</b>		<b>5,144,736</b>	<b>5,148,978</b>

<sup>a</sup>Rank is based on an average of oil reserves reported by *Oil & Gas Journal* and *World Oil*.

<sup>b</sup>Rank is based on an average of natural gas reserves reported by *Oil & Gas Journal* and *World Oil*.

<sup>c</sup>Member of the Organization of Petroleum Exporting Countries (OPEC).

<sup>d</sup>Includes one-half of the reserves in the Neutral Zone.

<sup>e</sup>Energy Information Administration proved reserves as of December 31, 1997 were published by the *Oil & Gas Journal* as its estimates as of December 31, 1998.

Note: The Energy Information Administration does not certify these international reserves data, but reproduces the information as a matter of convenience for the reader.

Sources: PennWell Publishing Company, *Oil and Gas Journal*, December 28, 1998, pp. 38-39. Gulf Publishing Company, *World Oil*, August, 1999, pp. 28-29.

adjustments.) A significant part of the total proved ultimate recovery appreciation came from the proved ultimate recovery appreciation of those new fields discovered between 1976 and 1998.

Similarly, the 1977 dry natural gas proved reserves were 213,278 billion cubic feet, and cumulative dry gas production from 1977 through 1998 was 388,917 billion cubic feet. Cumulative dry gas production exceeded the 1977 reserves, but at the end of 1998 there were still 164,041 billion cubic feet of dry natural gas proved reserves, for the same reasons. Only 13 percent of proved reserve additions of natural gas were booked as *new field discoveries* from 1976 through 1998.

## International Perspective

### International Reserves

The EIA estimates domestic oil and gas reserves but does not systematically estimate worldwide reserves. As shown in **Table 5**, international reserves estimates are presented in two widely circulated trade publications. The world's total reserves are estimated to be roughly 1 trillion barrels of oil and 5 quadrillion cubic feet of gas.

The United States ranked 12th in the world for proved reserves of crude oil and 6th for natural gas in 1998. A comparison of EIA's U.S. proved reserves estimates with worldwide estimates obtained from other sources shows that the United States had about 2 percent of the world's total crude oil proved reserves and over 3 percent of the world's total natural gas proved reserves at the end of 1998. There are sometimes substantial differences between the estimates from these sources. The *Oil & Gas Journal* reported oil reserves for the United Arab Emirates at about 98 billion barrels. This is about 50 percent higher than the *World Oil* estimate of 64 billion. One reason (among many) for these differences is that condensate is often included in foreign oil reserve estimates.

The *Oil & Gas Journal*{29} estimate for world oil reserves increased 1 percent in 1998, while the *World Oil*{30} estimate decreased less than 1 percent. For world gas reserves, the *Oil & Gas Journal* reported a 6 percent increase, while *World Oil* reported a 1 percent increase. The *Oil & Gas Journal*'s estimates were boosted mostly by increases in their estimate of gas reserves for Australia, Nigeria, and Saudi Arabia, but also because EIA proved reserves as of December 31, 1997 were

published by the *Oil & Gas Journal* as its estimates as of December 31, 1998.

Several foreign countries have oil reserves considerably larger than those of the United States. Saudi Arabian oil reserves are the largest in the world, dwarfing U.S. oil reserves. Iraqi oil reserves are almost 5 times U.S. reserves. Closer to home, Venezuela has almost triple and Mexico has around 81 percent more than the United States' oil reserves. (Based on averages of the World Oil and Oil & Gas Journal estimates).

### Petroleum Consumption

The United States is the world's largest energy consumer. The EIA estimates energy consumption and publishes it in its *Annual Energy Review*.{31} In 1998:

- The U.S. consumed 94,231,275,000,000 Btu of energy (94.23 quadrillion Btu).
- 62 percent of U.S. energy consumption was provided by petroleum and natural gas—crude oil and natural gas liquids combined (39 percent), and natural gas (23 percent).
- U.S. petroleum consumption was about 18.7 million barrels of oil and natural gas liquids and 58.3 billion cubic feet of dry gas per day.

### Dependence on Imports

The United States remains heavily dependent on imported oil and gas to satisfy its ever-increasing appetite for energy. In 1998, the U.S. was dependent on net petroleum imports for 51 percent of energy consumption.

Net gas imports increased slightly in 1998 to 3 trillion cubic feet, which is approximately 14 percent of consumption. Almost all of this gas was pipelined from Canada, some came from Mexico, though Mexico remains a net importer of natural gas from the U.S., and liquefied natural gas was imported from Algeria and Australia.

Venezuela, Canada, Saudi Arabia, Mexico, and Nigeria were the primary foreign suppliers of petroleum to the United States.{32}

## List Of Appendices

**Appendix A: Reserves by Operator Production Size Class** - How much of the National total of proved reserves are owned and operated by the large oil and gas corporations? Appendix A separates the large

operators from the small and presents reserves data according to operator production size classes.

**Appendix B: Top 100 Oil and Gas Fields** - What fields have the most reserves and production in the United States? The top 100 fields for oil and natural gas out of the inventory of more than 45,000 oil and gas fields are listed in Appendix B. These fields hold two-thirds of U.S. crude oil proved reserves.

**Appendix C: Conversion to the Metric System** - To simplify international comparisons, a summary of U.S. Crude Oil, Natural Gas, and Natural Gas Liquids Reserves expressed in metric units is included as Appendix C.

**Appendix D: Historical Reserves Statistics** - Appendix D contains selected historical reserves data presented at the State and National level. Readers interested in a historical look at one specific State or region can review these tables. We have again included Table D9, Deepwater Production and Proved Reserves of the Gulf of Mexico Federal Offshore 1992-1998, due to expressed interest from the industry regarding this area. Table D9 contains the production and proved reserves for 1992-1998 for the Gulf of Mexico Federal Offshore region by water depths greater than 200 meters, and less than 200 meters.

**Appendix E: Summary of Data Collection Operations** - This report is based on two EIA surveys. Proved reserves data is collected annually from U.S. oil and gas field operators on Form EIA-23. Natural gas liquids production data is collected annually from U.S. natural gas plant operators on Form EIA-64A.

Appendix E describes survey designs, response statistics, reporting requirements, and sampling frame maintainance.

**Appendix F: Statistical Considerations** - The EIA strives to maintain or improve the accuracy of its reports. Since complete coverage of all oil and gas operators is impractical, the EIA has adopted sound statistical methods to impute data for those operators not sampled and for those data elements that smaller operators are not required to file. These methods are described in Appendix F.

**Appendix G: Estimation of Reserves and Resources** - Reserves are not measured directly. Reserves are estimated on the basis of the best geological, engineering, and economic data available to the estimator. Appendix G describes reserve estimation techniques commonly used by oil and gas field operators and EIA personnel when in the field performing quality assurance checks. A discussion of the relationship of reserves to overall U.S. oil and gas resources is also included.

**Appendix H: Maps of Selected State Subdivisions** - Certain large producing States have been subdivided into smaller regions to allow more specific reporting of reserves data. Maps of these States identifying the smaller regions are provided in Appendix H.

**Appendix I: Annual Survey Forms of Domestic Oil and Gas Reserves** - Samples of Form EIA-23 and Form EIA-64A are presented in Appendix I.

**Glossary** - Contains definitions of many of the technical terms used in this report.